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Short communication

Duration of maternally derived antibodies in *Toxoplasma gondii* naturally infected piglets

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ABSTRACT

A longitudinal study was performed to analyze the dynamics of *Toxoplasma gondii* antibodies in naturally infected piglets from 1 to 25 weeks of age. Seventy-three piglets from 20 seronegative sows (modified agglutination test, MAT <1:25) and 20 naturally infected *T. gondii* seropositive sows (MAT ≥1:25) were analyzed at 1, 3, 6, 9, 12, 15, 18, 22 and 25 weeks of age. Twenty-six of the 73 piglets analyzed (35.6%; CI 95%: 25.5–45.7) were seropositive at some point during the study. Seroprevalence in piglets at 1 and 3 weeks of age was significantly higher in animals born from seropositive sows ($P < 0.001$ and $P = 0.02$, respectively) as an indication of maternally derived antibodies. The longest persistence (up to 6 weeks of age) was observed in piglets whose dam had high *T. gondii* antibody level (MAT ≥1:500), while persistence of maternally derived antibodies in the piglets born from sows with low antibody titers (maximum 1:50) was shorter and lasted only up to 3 weeks of age, when the piglets were weaned. The risk of horizontal transmission in piglets increased with age and was higher in piglets during the finishing period. The present results indicate that the decline of *T. gondii* maternally derived antibodies in naturally infected piglets is associated with the titers of their dams.

1. Introduction

Toxoplasmosis is a worldwide zoonotic disease caused by *Toxoplasma gondii*, which infects humans and most warm-blooded animals. Pigs are considered an important source of infection for humans and *T. gondii* can cause mortality in neonatal pigs (Dubey, 2009). There is a report of acute toxoplasmosis, including blindness in humans who had consumed undercooked pork (Choi et al., 1997).

The modified agglutination test (MAT) is considered specific for the diagnosis of *T. gondii* infection in pigs and it has been validated in pigs using isolation of the viable parasite as a guide (Dubey et al., 1995, 1996; Dubey, 1997). However, its efficacy for the diagnosis of *T. gondii* infection in neonatal pigs is unknown because of the presence of colostrally-derived antibodies in suckling pigs. In experimental infection, maternally derived antibodies have been shown to persist 3–4 months of age (Dubey and Urban, 1990) but there is limited information on *T. gondii* antibody dynamics and on the persistence of maternally derived antibodies in naturally infected pigs. In the present

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longitudinal study, piglets from *T. gondii* naturally infected sows were analyzed from 1 to 25 weeks of age to determine the decline of *T. gondii* maternally derived antibodies. The possibility of horizontal transmission in piglets born from seronegative sows was also evaluated.

2. Materials and methods

A farrow-to-finish herd with 240 sows on one location with a continuous flow production system (in nursery and finishing units) was selected for the present study.

Two–three piglets were randomly selected from 40 different sows of five different farrowing batches (total sampled 89 piglets). Piglets were all housed in similar conditions, received the same feed and were subjected to the same management practices (castration, iron injection, teeth clipping and tail docking). Piglets were ear-tagged at 1 week of age. They were weaned at 3 weeks of age and transferred to the nursery units, where litters from different sows were mixed. At 9 weeks of age, pigs were moved to the growing-finishing units and they were distributed taking into account the body condition. At 25–28 weeks of age, pigs were slaughtered. Housing, husbandry and slaughtering conditions conformed to the European Union Guidelines and Good Clinical Practices.

Blood samples (5 ml Venoject, Terumo Europe, Madrid, Spain) from all animals were taken at 1, 3, 6, 9, 12, 15, 18, 22 and 25 weeks of age. Additionally, a blood sample from sows was collected at 1-week post-farrowing (the same day as piglet sampling at 1 week of age). Only piglets with complete series of samplings were included in the study. The final data corresponded to 73 piglets (44 female and 29 male) (1–3 piglets analyzed/sow). Blood samples were centrifuged at $760 \times g$ for 10 min at 4 °C and the sera obtained were frozen at −80 °C until used.

Presence of antibodies to *T. gondii* was tested by the MAT as described previously (Dubey and Desmonts, 1987). The serum from each pig was initially tested at a dilution of 1:25. Positive or doubtful samples were re-tested at dilutions from 1:25 to 1:500. Positive and negative controls were included in each test. Sera from selected seropositive piglets (piglets positive at 1:25 dilution at 1 week of age) were further tested at 1:10 dilution.

Statistical analyzes were performed using SPSS software version 14.0 (Statistical Package for Social Sciences Inc., Chicago, IL, USA). The association between age classes was analyzed by means of a Pearson's chi-square test or, when there were less than six observations per category, by the Fisher's exact test. Differences were considered statistically significant when $P < 0.05$.

The effects of the age classes on seropositivity were analyzed by generalized linear mixed models (GLMM). The GLIMMIX procedure, implemented in the statistical software package SAS (version 9.1 SAS Institute Inc., Cary, NC, USA) was used for these analyses.

3. Results

The highest seroprevalence was observed in sows (50%; CI 95%: 34.5–65.5). Antibody titers in the seropositive sows were: 1:25 in 2 sows (10%), 1:50 in 16 sows (80%) and ≥1:500 in 2 (10%) sows. Nine seropositive sows (45% of the seropositive sows) had all the piglets (1–3 piglets analyzed/sow) seropositive to *Toxoplasma gondii* (Table 1), 3 seropositive sows (sow numbers 676, 673 and 597, 2 piglets analyzed/sow) had both seropositive and seronegative piglets in the same batch and, 8 seropositive sows had only seronegative piglets (1–3 piglets analyzed/sow).

Table 1
Toxoplasma gondii antibodies (MAT ≥1:25) in seropositive piglets during the longitudinal study (1, 3, 6, 9, 12, 15, 18, 22 and 25 weeks of age) and in their dams.

Seropositive piglet no.	Sow number (seropositivity)	Persistence of antibodies (weeks)
51	505 (positive)	1
64	451 (positive)	1, 6, 9, 12
87	505 (positive)	22
96	505 (positive)	1
117	446 (negative)	18
130	535 (positive)	1, 3
182	557 (positive)	1, 3
193	557 (positive)	1, 3
194	557 (positive)	1
213	536 (negative)	25
234	637 (positive)	1
248	536 (negative)	22, 25
263	700 (negative)	25
298	536 (negative)	22, 25
305	622 (positive)	1, 22
315	622 (positive)	1, 3
346	566 (positive)	1, 3
350	586 (negative)	15, 18, 22
354	622 (positive)	1, 15
361	597 (positive)	1
394	565 (positive)	1, 3
402	712 (negative)	22, 25
478	676 (positive)	1
489	673 (positive)	1, 9
495	614 (positive)	1, 3
3003	778 (negative)	25

Twenty-six of the 73 piglets (35.6%; CI 95%: 25.5–45.7) were seropositive at MAT ≥1:25 at some time during the study period. Eighteen (69.2%) of these seropositive piglets were born from seropositive sows (Table 1). Seroprevalence in piglets at 1 and 3 weeks of age was significantly higher in animals born from seropositive sows ($P < 0.001$ and $P = 0.003$, respectively). Seventeen (65.4%) of the 26

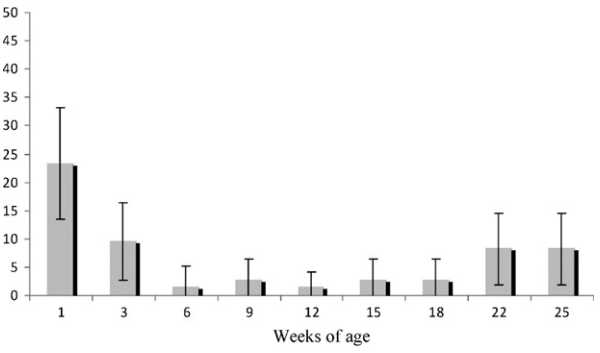

Fig. 1. Seroprevalence (percentage and 95% confidence limits) of *Toxoplasma gondii* antibodies (MAT ≥1:25) in the different age classes of piglets (weeks).

piglets born from seropositive sows had antibodies the first week of age and 7 of those piglets (21.2%) remained seropositive at 3 weeks of age. The piglets seropositive (MAT ≥1:25) at 3 weeks of age were seronegative at 6 weeks of age. No significant association was observed among seropositive sows and piglets older than 6 weeks of age. Distribution of seroprevalence in the different age classes is shown in Fig. 1.

The longest persistence of maternally derived antibodies was observed in one piglet (animal 64) born from a sow with high titer of antibodies against *T. gondii* (1:500) (Table 1). Although the piglet was seronegative (MAT <1:25) at 3 weeks of age, in a second analysis performed using MAT at 1:10 dilution, antibodies were also observed at every time point up to 12 weeks of age. This piglet also had the highest titer (≥1:500 at 9 weeks of age). Another piglet born from the only other sow with high antibody titer had antibodies up to 6 weeks of age when analyzed at 1:10 dilution. In piglets born from seropositive sows with lower titers (maximum 1:50) the maximum duration of consecutive positive antibodies analysis was up to 3 weeks of age, even when analyzed at 1:10 dilution.

The 8 seropositive piglets born from seronegative sows were positive after 15 weeks of age. At that age, these piglets were in the finishing units and significantly higher seroprevalence was observed in the finishing units compared to the growing units.

Statistically significant differences between sexes were not found in the different age classes.

4. Discussion

The present longitudinal study on naturally *Toxoplasma gondii* infected piglets showed a significant association between seropositive sows and seropositive piglets at 1 and 3 weeks of age respectively, which suggests that the antibodies present at those ages were maternally derived. The longest duration of maternally derived antibodies was observed in piglets born from sows with high titer *T. gondii* antibodies (up to 6 weeks of age). In experimentally induced toxoplasmosis in pigs the presence of maternally derived antibodies was detected up to 90–120 days after birth (Dubey and Urban, 1990). In naturally infected pigs in the present study the duration of maternally derived antibodies was shorter and antibodies declined shortly after being weaned at 3 weeks of age. The sharper decline of maternally derived antibodies in naturally-exposed piglets was probably due to low levels of *T. gondii* antibodies in their dams.

In some seropositive piglets born from seronegative sows the antibodies were first detected at 15 weeks of age. These data indicate post-weaning horizontal transmission of *T. gondii*. In addition, the fact that 3 piglets seropositive at the first week of age, negative in the subsequent samplings, become seropositive again later in the study, could be also due to horizontal transmission in those animals. Similarly, the high titer of antibodies against *T. gondii* (≥1:500) observed in the animal 64 at 9 weeks of age could probably be due to post-natal infection at that time.

The risk of horizontal transmission in piglets was higher in piglets during the finishing period. This could be due to the more hygienically relaxed management conditions in this period and the presence of outdoor facilities in growing-finishing units in the herd. These conditions increase the possibility of contact with cats and rodents at that stage, thus increasing the probability of ingestion of oocysts and tissue cysts, respectively (Venturini et al., 2004).

In conclusion, the present results indicate that the decline of *T. gondii* maternally derived antibodies in naturally-exposed piglets seems to be related to the titers of their sows and that colostrally acquired antibodies decline shortly after weaning. The possibility of horizontal transmission in piglets increased with age and was higher in piglets during the finishing period.

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